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ABSTRACT

After reviewing the physical plant environment and temperature control equipment at Eastfield College (Texas), this paper explains how redirected efforts toward energy conservation can result in important cost/usage savings. Electricity billing rates are explained to provide a stronger usage strategy for cost effectiveness. Two methods of reducing peak energy demand levels are considered: (1) a computerized system that automatically shuts down heating and cooling elements when the identified tolerable peak demand load is approached; and (2) an approach which emphasizes the reduction of overall kilowatt hour usage by turning off lights and adjusting thermostats. The assumptions upon which this second approach is based are outlined, and methods of monitoring utility consumption and of implementing this energy conservation plan are presented. (MB)

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ENERGY CONSERVATION: IMPLEMENTING AN EFFECTIVE CAMPUS PROGRAM

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INTRODUCTION

Energy efficiency programs have become so familiar that the expression "Energy Conservation" denotes a tone of helpless passivity. People are universally tired of talking about energy conservation because nothing appears to have originated beyond a few haphazard efforts to turn off the lights when not in use.

Yet at Eastfield College, electricity and gas costs increased approximately 14% ($50,938) from 1976-77 to 1977-78, representing an energy consumption (electricity/gas) bill of $365,275. While the college experienced minor reductions in actual utility consumption (1.1% CCF/gas and 3% KWH/electricity), economy of energy usage did not approach the savings experienced at other campuses. Reduction in electricity (KWH) usage reached 16% at El Centro and Richland. Reduction in natural gas consumed (CCF) was 6.5% at Mt. View and 17% at Richland.

The apparent unresolved Eastfield issue of energy conservation must be approached from a far different perspective if stable utility costs are to be achieved. The approach for saving energy at Eastfield is the same as that used in homes -- turning off lights when not in use. What isn't realized is that total energy usage for lighting in homes accounts for only 3% of the national energy consumption amount. While Eastfield's micro-environment requires a significantly higher percentage of energy to light its facilities, the major portion of the electricity is used to heat and cool the classrooms. Efforts to turn off lights have been beneficial in reducing peak loads and improving employee energy consciousness, but apparently minimal in effecting any meaningful cost savings or overall utility reductions.

This paper will attempt to explain how redirected efforts may result in important cost/usage savings. The behind-the-scenes physical plant environment will be lightly reviewed to lay the groundwork for several operational recommendations. Electricity billing rates will be explained to provide a stronger usage strategy for cost effectiveness. Improved methods of monitoring energy consumption will be presented. Finally, recommendations relating to a proposed energy plan will be identified.

PLANT OPERATION - TEMPERATURE CONTROL EQUIPMENT

If the effect of reducing electricity usage by turning off light switches is minimal, what alternative approaches to energy conservation can be taken? The answer lies behind the scenes, in the boiler room, where a large amount of energy is consumed to heat/cool the campus environment. The following is an overview of the physical plant heating/cooling facilities, which should assist in providing basic information needed to comprehend current energy usage patterns and related operational recommendations. Lack of data restricts the ability to quantify consumption amounts. Estimated electrical dollar savings in several proposed utility usage plans will be discussed later (Electricity - Cost/Usage Reduction Plan).

Plant Operation

At one end of the myriad pipelines leading to and from the living/working zones on campus, is an operating system that is rarely thought of and less frequently explored -- the engineering plant. Similar to the function performed by the human heart, the boiler room monitors and pulsates warm and cool air throughout the campus, maintaining a stable and more tolerable environment than the alternative presented by outside elements. Design limitations, unfortunately, make this "life support system" a much more expensive and less efficient function than its biological counterpart.

For instance, use of the Performance Hall on a Saturday night requires the total campus facility to be heated/cooled accordingly. Boiling water required in the kitchen or classroom labs requires the entire domestic water system to be raised to boiling temperature. Segregated temperature control zones for isolated use was not provided in the facility design. Separate water heaters for isolated use have not been incorporated into the facility usage concept. The net result is a frequently inefficient utilization of facilities when the total campus environment must be prepared for small numbers of users.

The heating/cooling system operates on a dual duct system. Cold and hot air is continuously circulated through the ventilation system. Adjustments to room temperature are made by altering the correct mix of hot and cold air as determined by area thermostats and mixing boxes.

Boiler - Hot Steam

Eastfield currently has two natural gas generated boilers. Water heated from the boilers' steam is diverted by three heat exchangers to warm the pool, domestic water and the facilities. The amount of energy consumed by the boiler is contingent upon how much heat is required by each of the heat exchangers. Obviously, closing or restricting the pool heat exchanger would be one method of reducing utility demands. Eliminating the domestic water heat exchange on weekends and during non-working hours (assuming non-custodial needs) may also be beneficial.

Currently, natural gas is the only resource used to "fire" the boilers. Since Eastfield is a single-source user, guaranteed supplies of natural gas

are obtained by paying a higher residential rate. The boiler does have the capacity to be converted to multiple-source usage -- natural gas and fuel oil. Boiler conversion to permit multiple fuels would provide reduced rate options not currently permitted.

Comparison of industrial rates for natural gas purchased at El Centro (dual source user) and Eastfield residential natural gas rates during the heavy usage periods of October through March of 1977-78, indicated a rate savings to El Centro of approximately 32%. A similar rate for Eastfield during the same period would have resulted in an approximate savings of $19,169.

Before recommending any conversion of facilities based on resource rate differentials, it is critical to realize that rates are not stable and are subject to wide fluctuations. Any long term analysis of return on investment when payback is determined on rate differentials must be approached with caution.

Chillers - Cooling System

While the boilers are creating steam, the chillers (2) are simultaneously refrigerating water. The chillers are prime users of electricity. Potential major cost saving practices are identified later under the heading Electricity - Cost/Usage Reduction Plan.

The cooling function involves a dual process of recycling "cooling" water from cooling towers. which rechills circulating water returned from basement coils. After cooling, the chilled water is returned to one of three basement cooling coils. Air circulated by the air-handling fan passes through a cooling coil, refrigerates, and is then forced into one of the dual ducts used for ventilation.

Several operational and maintenance practices are available to reduce energy expended to operate the chillers, including:

1. Periodically cleaning the cooling coils to help assure efficient ventilation/cooling is taking place. Maintenance requires total plant shutdown.

2. Each of the three basement locations where the cooling coils are located have fresh air louvers that open automatically when outside temperatures drop to 55° or less. This permits the chillers to cutback or turn-off since outside air becomes chilled air. Louvers must have periodic maintenance for operational efficiency. The cost-benefit relationship depends in part on the time the chillers could actually be shut-off.

Mixing Boxes/Thermostats

Air handling fans pull expended/stale air from the buildings. Return air is pulled through either the hot or chilled coils by the return air fan for recirculation via the dual duct ventilation system. Warm or cool air is taken from the ventilation system by mixing boxes, as dictated by room/area thermostats.

Users can collectively affect energy consumption by adjusting thermostats to reduce the amount of cool or warm air required. Total benefit, similar to turning off the light switch, is difficult to determine quantitatively.

With the exception of savings obtained from maximizing downtown, which is discussed in the next section, a high degree of plant operating efficiency should result in significant energy conservation. Maintenance of a heated pool during winter, domestic hot water during off hours, etc. may be a habit that has become an extravagance. Planned maintenance, shared District-wide information on maximizing chiller/boiler operation efficiency, should also be included in any energy conservation plan.

ELECTRICITY - COST/USAGE REDUCTION PLAN

Since electricity costs represent approximately seventy-five percent of the total utility (excluding water) bill, the primary cost saving efforts of this paper have been directed towards the analysis of electrical usage and related billing rates. Findings should result in a stronger usage strategy for developing an effective cost reduction plan.

Determination of Demand (kW)

The Texas Power and Light Company billing rate is divided into two distinct segments. The first relates to kilowatts (kW) of demand, identified in items "A" and "B" below. The second relates to kilowatt hours (kWh), item "C" below.

The net electricity billing rate for Eastfield as provided by Texas Power and Light is:

A. $115.00 for the first 20 kW, or less, of demand;

B. $4.45 per kW for all additional kW of demand; and

C. $1.65 per kWh for the first 8,000 kWh,
1.20 per kWh for the next 42,000 kWh,
.80 per kWh for the next 50,000 kWh, and
.46 per kWh for all additional kWh.

To analyze the kilowatt billing rate, it is necessary to define the term "demand." Demand is the kW supplied during the 15-minute period of maximum use during the current month, as determined by the company's (TP&L) demand meter, but not less than 70% of the maximum kW similarly determined during the billing months of June, July, August, September, or October in the 12 months ending with the current month, nor less than 20 kW.

Usage date captured on TP&L;s meter cassette tape, is transferred to computer printouts. Information is presented in 15-minute kW intervals throughout the billing period. The highest single peak 15-minute period is identified as demand, and billed according to the formula in "A" and "B" above.

Two conclusions can thus be drawn. Identifying and reducing peak periods can result in a lower kW demand and help lower kW billing rates. Also, lowering the kW demand during the peak summer months will permit winter billings to drop below the current existing peak demand minimum of 70% of maximum usage levels defined above.

There are several methods of reducing peak load demand levels. Currently, Richland and Mountain View have a System-7 computer that automatically shuts down various electrical heating and cooling elements when the identified tolerable peak demand load is approached. An alternative, and less expensive, approach will be discussed later.

The main question is, "What cost savings can be obtained by reducing demand kW, and will the cost savings justify the effort?"

Analysis of peak demands for the months of August/September and October/November indicated that even under optimum conditions, savings would not have exceeded $431.65 per month. Refer to Exhibit I - Demand (kW) Cost Analysis. Actual savings based on more normal fluctuations of 20 or less kW's indicate actual peak load savings would be less than $89.00 per month. It does not appear that reducing peak load demand levels by excessive monitoring would result in significant cost savings.

The second, and more profitable approach, appears to be to emphasize the reduction of overall kilowatt hour (kWh) usage.

During the highest billing month of August, 1978, ($25,514.69), 87% of the invoiced amount related directly to kWh usage.

Several assumptions need to be highlighted:

1. During the month of August, the highest daily electrical consumption totaled 39,885 kWh on Wednesday, September 20, 1978. The lowest daily utility usage totaled 13,118 kWh on Sunday, September 3, 1978. Difference in kWh cost between maximum and minimum day totaled $320.00.

2. Maintaining the cooling/heating system after 11:00 p.m. until 5:30 a.m. averaged 1200 kWh per hour in excess of estimated minimum usage levels (800 kWh/hour). Actual daily additional cost equals $93.60. Annual cost, assuming 266 work days, equals $24,897.

3. It does not appear to require additional kWh or kW to bring Eastfield facilities back to normal temperature after a weekend of not using chillers.

4. Keeping facilities open and temperature adjusted for weekend usage averages approximately 10,000 ($120.00) additional kilowatt hours per day. Based on 1977/78 Eastfield calendar of events, the campus remained open seventy-one weekend days for an approximate total annual electrical cost of $8,520.

5. Potential savings from closing the facilities on weekends may possibly be increased by re-evaluating methods of adjusting chillers/boilers to reduce minimum kWh levels.

6. It is unlikely that total physical plant shut-down can be achieved during extreme outside temperature levels without potentially damaging pipes, classroom specimens, and inside plants.

The strongest usage strategy appears to be directed towards reducing daily kWh usage. Peak load adjustments can bring minor reductions in billing amounts. As explainge above, concentration efforts towards reducing total kWh by turning the plant chillers/boilers down or off during weekends and nightly may result in significant estimated electricity cost savings of $33,417 (12.5% of total cost).

Of primary concern relating to shutting down the heating/cooling system at night is the effect it will have on the night custodial shift. Even with an approximate two-hour temperature time lag before building temperatures begin to adjust to outside environment, manpower usage patterns would have to be re-evaluated. Buildings available for early evening cleaning (Administration) will have to be identified. Mid-day cleaning of restrooms may need to be considered. Classroom schedules could dictate time cleaning can be accomplished. Experimentation with temperature change will have to be monitored.

On the positive side, plant operators will not be required during the late shift. Time will be available for preventative maintenance on weekends. Reductions in compensatory time off should result.

Equally apparent, the cost of keeping facilities open to outside (including Community Service) usage should be considered. When possible, utility cost should be assumed by the user.

MONITORING UTILITY CONSUMPTION

Currently, invoices from Lone Star Gas and Texas Power and Light are sent directly to District Accounting for processing and payment. While this procedure restricts the ability of campus personnel to monitor consumption habits in a timely manner, adequate gas and electrical detail information is available from alternative methods to provide accurate usage patterns.

Electricity

Texas Power and Light accumulates kilowatt information from on-campus meters. The club house and parking lights are recorded on one, all other campus consumption on the second.

Data captured on cassette tapes is removed on the 20th of each month. A TP&L printout is produced indicating kW usage by the quarter hour, total kilowatt hours by day, total monthly kilowatt hours and peak demand kW. See Exhibit I in Appendix. This monthly report is available from TP&L upon request. Analysis of electrical consumption habits by the quarter hour will enable campus personnel to:

1. Determine peak usage times (i.e., 11:00 a.m. and 6:00 p.m. to 7:00 p.m.);
2. Determine whether energy-saving procedures are working;
3. Better allocate the usage of high electrical consuming equipment (kitchen, kiln, electrical welding) to low consumption periods; and,
4. Help identify when surplus spaces (i.e. administrative offices) need to be darkened to compensate for high-usage early evening periods.

In addition to the monthly printouts, TP&L will provide, upon request, a printout summary of total charges by month for the current and previous 12-month period.

The availability of data relating to consumption of electricity is abundant. It is critical to the implementation of a successful energy plan to assure that such data is not only obtained, but also made available to as many employees as possible.

Gas

Detailed information provided by TP&L does not appear to be available from Lone Star Gas. Consumption (CCF) should be forwarded to the campus after payment by Accounts Payable.

More campus detail can be obtained by taking frequent meter readings. Changing shifts could be assigned the task of recording gas readings. Experimentation regarding various plant operation changes (i.e., heat exchangers turned off, single vs. multiple boiler operation, different temperature settings) will have more meaning if normal consumption levels can be identified.

IMPLEMENTING AN ENERGY CONSERVATION PLAN

While turning off light switches and adjusting thermostats is an obvious energy-saving process, the added variables of human nature and multiple users makes such an energy conservation plan difficult to incorporate and maintain. Following are recommendations addressed above that should begin an effective energy conservation plan.

1. Discontinue 24-hour operation (M-F) of the physical plant for cooling and heating purposes. Eastimated electrical savings - $24,897.

2. Close facilities on weekends and holidays. Estimated electrical savings, based on prior 12-month weekend usage - $8,520.

3. Evaluate the need to maintain a heated pool during winter or summer months.

4. Investigate the need for maintaining domestic hot water supplied by central boilers. Can localized water heaters perform the same function for less? Can specific times be identified when hot water is needed, so domestic heat exchangers can be closed when not needed?

5. Investigate the cost benefit of converting to a dual source resource user to take advantage of lower rates.

6. Shift current night staff to weekend hours, allowing planned maintenance for physical plant possible only when system is down.

7. Investigate the cost benefit of repairing and maintaining fresh air louvers.

8. Identify high users of electricity and schedule around high peak demand periods.

9. Attempt to locate where energy is being consumed during off-hours to reduce minimum demand levels when campus is closed.

10. Identify permissible temperature levels that will not damage pipes, classroom specimens, inside vegetation, etc., when reduced plant operation on weekends exposes the inside of the facility to extreme outside temperatures.

11. Improve monitoring and experimentation of utility consumption by:

    a. Obtaining Texas Power and Light Company monthly printouts.

    b. Obtaining and communicating billing invoice information to Physical Plant personnel.

    c. Beginning frequent manual gas meter readings. Use the data obtained to determine the effectiveness of experimentation with various plant operating procedures.

12. Encourage, organize, and participate in District-wide experimentation including:

a. Temperature retention capabilities of facilities

b. Temperature change levels for optimum operating efficiencies

c. Single versus multiple chiller/boiler units in operation

d. Alterations of temperatures on heating and cooling deck

e. Cost of returning facilities to normal temperatures

f. Minimum time required to adjust temperatures efficiently and economically

g. Methods of reducing minimum kilowatt hours during p.m. and weekend periods.

13. Communicate to campus personnel relevant information (i.e., peak usage times) to help incorporate an energy consciousness.

Experimenting with different levels of optimum operating efficiency should be encouraged by the Administration. Physical Plant operators understand the various approaches that can be taken to reduce utility usage. What is required is an understanding and commitment by all parties that adjustments will be necessary to current methods of operation. What needs to be identified and communicated is how much adjustment is acceptable.

APPENDIX

EXHIBIT I

DEMAND (kW) COST ANALYSIS

August - September

0726	kW Peak Demand @ 11:00 a.m. - 9/5/78
0629	kW Low Demand from 8:00 a.m. to 3:00 p.m. - 9/5/78
97	kW fluctuation
x 4.45	per kW
$431.65	Cost in excess of Minimum Demand for same period

October - November

0658	kW Peak Demand @ 7:45 p.m. - 10/25/78
0608	kW Low Demand from 9:00 a.m. to 9:00 p.m. - 10/25/78
50	
x 4.45	per kW
$222.50	Cost in excess of Minimum Demand

NOTE: The wide fluctuation indicates that a wide variation of kW's are consumed during the normal working day. Actually, kW's do not normally fluctuate more than 10-20 kW's per hour over a six to ten hour period. Actual monthly savings by reducing the peak demand period to the next optimum level would not exceed $90.00. 20 kW x $4.45 = $89.00.

Exhibit II was removed from this document prior to its being submitted to the ERIC Document Reproduction Service.

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